

Personal Digital Assistants

Richard H. Wiggins III, MD

Personal digital assistant sales are growing exponentially, and as medical technology advances the amount of information available becomes staggering, making a handheld device, with the ability to store a great amount of information, progressively more valuable to health care providers. Mobile computing allows for a great deal of knowledge in a small package, creating a “walking library” with a mobile collection of data always accessible. There are many diverse types of PDAs, and this article discusses the history of PDAs, general purchasing issues, general PDA features, and the most significant differences between the Palm and the Windows CE operating systems.

KEY WORDS: Personal digital assistant, PDA, handheld computers, wireless networks

PERSONAL DIGITAL ASSISTANTS (PDAs) are also known as handheld computers, pocket computers, and palmtops, and their sales are growing exponentially. These devices have continued to grow in popularity even during periods of economic downturn. The original Personal Information Management (PIM) devices have evolved into advanced units with communication, entertainment, and wireless capabilities. Most are pen-controlled devices, with networking, and some even include voice recognition abilities. The term “PDA” includes “smart” pagers, Internet appliances, palm-size computers, and wearable computers.^{1,2} Healthcare, and especially radiology, is evolving rapidly as technology speeds diagnostic imaging abilities. With technology advances, the amount of available information becomes staggering, making portable device with the ability to store a great amounts of information increasingly valuable. Mobile computing allows us to carry a great deal of knowledge in a small package, in a way impossible a decade ago,

creating a “walking library” with a collection of data, including radiologic images, always accessible (Fig 1).

Apple launched the first PDA the Newton MessagePad, in 1993. In the year 2000, nearly 12 million PDA units were sold worldwide. These numbers are now expected to increase exponentially for the next decade.³ This trend will continue to increase, and will pass the number of desktop computers sold per year this decade. The use of PDAs in medicine will also grow exponentially. The ability to carry a significant amount of information on disease processes, laboratory values, and for radiologists, images showing examples of various diseases can greatly influence medical care. In addition, advances in wireless technology will allow interaction between PDA devices and a hospital network, such that laboratory values and radiologic images can be accessed from a network at any location inside a wireless networked institution.^{1,4,5} The next generation of radiologists will be the first to have easy computer access, and they will not only understand and accept this technology, they will expect digital interactions in their everyday activities. This technology is constantly evolving, which makes an article like this one difficult to create,

From the Department of Radiology, Division of Neuroradiology, 1A71 University Hospital, 50 North Medical Drive, Salt Lake City, Utah 84132-1140, USA.

Correspondence to: Richard H. Wiggins III, MD, Director of Radiology Informatics, 1A71 University Hospital, 50 North Medical Drive, Salt Lake City, UT 84132-1140; e-mail: Richard.Wiggins@hsc.utah.edu

Copyright © 2004 by SCAR (Society for Computer Applications in Radiology)

Online publication 17 February 2004

doi: 10.1007/s10278-003-1665-8

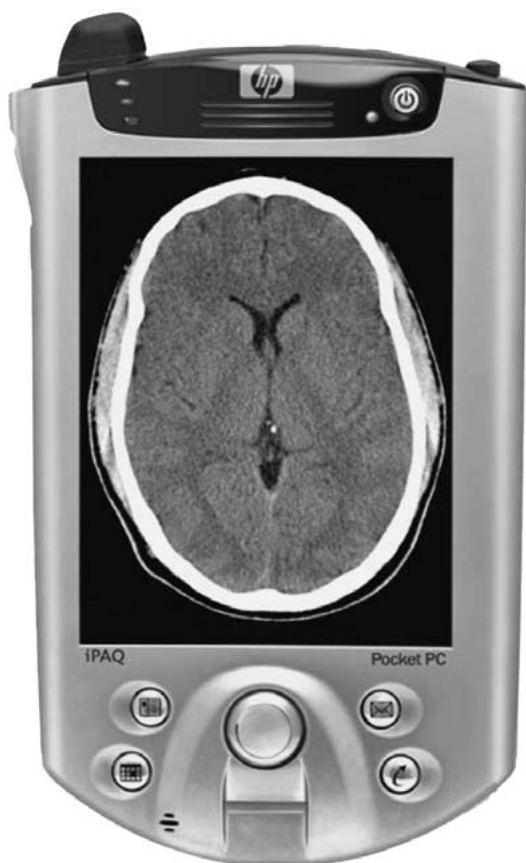


Fig 1. An axial standard algorithm Computed tomography (CT) image through the head displayed on a Hewlett-Packard iPAQ.

especially with inclusion of up-to-date information.

Among the many types of PDAs now available are Palm OS units, Windows CE, Symbian OS PDAs, Tablet PCs, Blackberry devices, “smart” watches, “smart” pagers, and cellular phones with PDA functions. The palm and the Pocket PC are the most popular PDAs overall, and they have the largest user base; therefore they are the focus of this discussion, which explores PDA history, purchasing issues, special features, and the most significant differences between the Palm operating system (OS) and the Pocket PC 2002 OS.^{1,5,6}

PDA HISTORY

A graduate student at the University of Utah in the 1970s, Alan Kay, first described the PDA.

His idea was to have an interactive computer similar to a book with wireless communications abilities and a flat panel display. The device he described was called the Dynabook. It took technology three decades to catch up with his idea. The Dynabook prototype was actually created in the 1970s by the Palo Alto Research Center (PARC), from Xerox, but was never developed to market. It did lead to the development of both laptop computers and PDAs. The PARC group is the same group that came up with the mouse (later popularized by Apple), and now running on almost all desktop computers, as well as the What-You-See-Is-What-You-Get (WYSIWYG) Graphical User Interface (GUI), which Apple popularized, and which was later adopted by Microsoft.^{4,7,8}

In the early 1980s, the business world depended on the “week-at-a-glance” Day-Timers (Fortune Brands, Inc., Lincolnshire, IL) to organize names, contact numbers, schedules, and to keep track of important dates. Over the next decade, however, this paper system evolved into the digital environment, led by the Psion devices, first released in 1984. These units were able to combine a calendar and a clock with a simple calculator, and a simple database. More important, however was some expansion capability. In the same year, Research in Motion (RIM) was founded, specifically targeting the wireless communications market. RIM has now joined with cellular phone companies to create the Blackberry (Research In Motion Limited, Waterloo, Ontario, Canada) PDA device, with Java-based integration of a telephone with e-mail services, including a built-in QWERTY keyboard. In the early 1990s, Casio released the successful Databank[®] (Casio Computer Co., Ltd., Tokyo, Japan) watch line, offering a small source for basic personal information management (PIM). These small devices allowed the user to keep dates, names, addresses, phone numbers, and memos in a small package. Modern versions of these watches now include Global Positioning Systems (GPS) and even low-resolution digital cameras, as well as integration with the Palm OS.^{1,6,9,10}

John Sculley, then CEO and Chairman of Apple, first described the term “PDA”.⁵ The first PDA was the Newton MessagePad, developed by Apple and introduced in 1992 and

available in 1993. The Newton was a revolutionary product, creating an entirely new market, and 80,000 units were sold in 1993. This was the first device to include character recognition for the input of data. The handwriting recognition abilities were somewhat limited, and there was little infrared support. This technology was not advanced to the point where such a device could be produced at an affordable price, and Apple was forced to leave the PDA market in 1998, after releasing several models.^{5,7,11}

Palm, Inc., founded in 1992 (and acquired by U.S. Robotics in 1995), released the first Palm Pilot device in 1996. This PDA had much improved handwriting recognition, and a refined GUI. The Palm Pilot 1000 was smaller, faster, and cheaper to make than the Apple MessagePad. Palm began licensing the Palm OS platform in 1997, and was the first to release a PDA device with wireless Internet access, the Palm VII, using its own Internet Service Provider (ISP), Palm.Net, in 1999. Palm released the wireless i705 also using the Palm.Net always-on wireless service, with unlimited coverage in almost all major metropolitan cities. This unit has 8 MB memory, and can store 400 e-mail messages, 10,000 addresses, 5 years of appointments, 3,000 memos, and runs with the lithium rechargeable battery, lasting about a week between charges. The i705 has an expansion slot compatible with Secure Digital and MultiMediaCards. The display, however, is a transreflective monochrome with a backlight. Palm then released the m515 with an improved adjustable backlight display, and 16 MB internal Random Access Memory (RAM) with the Secure Digital and MultiMediaCard capabilities. In 2002, Palm released two devices aimed at either end of the PDA market, the low-end Zire with only 2 MB RAM, and a monochrome display, and the Tungsten, with 16 MB RAM, and an improved 320 × 320 color display, and running the new Palm OSv-5.0 and a faster Open Media Applications Platform (OMAP) 1510 processor (enhanced ARM-based), from Texas Instruments, similar to the Pocket PC 2002 devices. These models were soon followed by the Tungsten T2, with an increase in the amount of RAM to 32 MB, the Tungsten W phone unit, and the Tungsten C with 64 MB

RAM and built in wireless fidelity (Wi-Fi). Oddly, the Tungsten series from Palm uses three different processors, with the older Motorola 33 MHz chip in the W, The OMAP 144 MHz chip in the T2, and the Intel XScale 400 MHz CPU in the Tungsten C unit.^{5,11-14}

Microsoft quickly recognized the importance of the PDA market and in 1996 launched the Windows CE OS. This was an interesting move by Microsoft, in that they created the software but relied on other companies to manufacture the hardware to run the OS. This attempt to “port” the Windows desktop OS to a PDA device was not initially successful. The first Windows CE v1.0 included a monochrome display, and was hindered by short battery life, instability problems with the OS, limited abilities, and a poor GUI. The next version, Windows CE v2.0, added color support for displays, and improved stability, and v2.1 added support for a Reduced Instruction Set Computer (RISC) processor a year later in 1997. A direct move by Microsoft to compete with the increasing Palm market was the release of devices without a small keyboard. These devices had similar problems with short battery change life, stability, and synchronization difficulties.^{6,11,13}

The much improved Pocket PC OS was then released in early 2000, followed in late 2001 with Pocket PC 2002 OS. Microsoft again called upon the vendors creating hardware for them to meet standards for the new OS. These Standards included hardware requirements for a new display standard and use of the new ARM processor. The first units on the market utilized the StrongARM 206 MHz processor from Intel, which promised lower power use, lower cost, and increased performance. They were developed by Compaq, HP, Casio, and Toshiba. The vendors also added an improved GUI, and multimedia features. These units also included a stylus for the input of data into the device. The keyboard-based Windows CE units evolved into the less popular Handheld PC Pro units still manufactured by NEC, Intermecc, and HP.^{11,13-16}

This is a complex development pathway, with an array of new terms, Windows CE, Pocket PC, and Handheld PC. The name “Windows CE” defines the OS, and the names “Pocket PC” and “Handheld PC” refer to specific types

of mobile devices. A Pocket PC is any device that has a quarter VGA (320×240) screen, and a Handheld PC is any device that has a half VGA (640×240) or full-size (640×480 or 800×600) screen with or without an integrated keyboard. Other Windows CE-based devices from Microsoft include the X-Box and the Smart Phone.^{13,15,17}

Psion released a PDA called “EPOC,” which later became the name of the OS running on these devices. Psion licensed the OS in 1997, and joined with Nokia, Motorola, and Erickson in an effort to produce the next generation of wireless PDA devices using the EPOC OS, to form Symbian. The 32-bit Symbian OS attempts to allow for multi-tasking, integrated telephony, communications protocols, data management, and advanced graphics support, focusing on the wireless market.^{5,6,11}

In 1999, Palm controlled 70% of the PDA market, with an over 5 million-user base. The greater battery life and user friendly GUI of the Palm OS led to its popularity over the early Windows CE units. The significant advances of the Windows Pocket PC 2002 OS will decrease the Palm OS market share, as the enterprise market begins to adopt wireless technology, such as Bluetooth, and combination PDA and cellular phone units. PDA sales are growing exponentially, and are expected to reach 58 million units by 2008.^{3,11,17,18}

PDA SELECTION

There are three general types of PDA users. The first type wants a device to keep track of PIM data, such as names, addresses, and phone numbers, as a compact digital replacement for the paper Day-Timer; such users will likely never use expansion cards or multimedia applications. The second kind of users are more tech-savvy, always looking for the latest “cool toy,” but their PDAs may end up sitting on the shelf for days at a time. The third type is the power user (or enterprise environment user), who is interested not only in basic PIM (if at all), but also organization applications, such as working with Microsoft Office documents and/or connecting to a wireless network.

Most users outside of an enterprise environment will consider cost a significant issue in

PDA purchasing. Generally, devices under \$200 will have a gray scale display, with minimal memory, a slow processor speed, and basic expansion capabilities such as Compact Flash (CF), Secure Digital Card (SDC), or Multimedia Cards (MMC). These PDAs will be used mostly for PIM. Devices in the \$200–\$400 price range will be used for PIM, but they also have the ability to handle applications such as Web browsing and multimedia. These units will have more RAM, slightly faster processors, and more expansion capabilities, such as CF, SDC, MMC, and the Sony Memory Stick. The highest priced PDAs, over \$400, will include the new Pocket PC (PPC) 2002 units, with more RAM (32–128 MB), higher processor speeds (200–400 MHz and higher), and higher resolution color displays (65,000 colors). These devices feature the most expansion capabilities, often including built-in Bluetooth short range radio technology and/or Wi-Fi network capabilities.¹⁹

In general, the PDA neophyte who is looking for basic PIM and reliability will gravitate to the Palm OS, and the middle type of user will find attractions in both operating systems. The power user and enterprise solution manager will likely gravitate toward the PPC devices, for their increased wireless capabilities, as well as the high-end Palm OS devices.

PDA FEATURES

Data Input

The pen-stylus is the most commonly used method for PDA data input, using a form of handwriting. There are also touch-sensitive screens and portable keyboards. The Palm OS utilizes the Graffiti system, which defines characters by unique patterns, for example, an “a” is written as an upside down “V”, like this: “人”. The original recognition method of the Newton “learned” how the user preferred to write individual characters, so that the character recognition increased with use, and even allowed for multiple user recognition profiles on a single unit. The Graffiti method used by Palm OS devices is different, in that the PDA teaches the user how to write characters. There are also various touch-sensitive screen keyboard tech-

nologies, and voice recorder capabilities for data input.

Synchronization

The ability to have synchronization of data between a PDA and a desktop computer has greatly increased the usability of PDAs. Most devices dock with a type of cradle that attaches to the device while synchronizing, and there are also infrared and modem options. The Palm OS devices use Palm desktop software on a Windows or Macintosh computer as another method of data input. The Pocket PC 2002 units use ActiveSync technology to continuously synchronize data between the PC and the PDA, with user-defined folders on the desktop system. These units have scaled-down versions of Microsoft Word and Outlook for transmission of files between the PC and the devices. Palm OS devices can also use programs to view Microsoft Word and Excel files.^{6,14,17}

Displays

The PDA display technology has evolved in much the same way as laptop computers. The first Psion device had a simple 16-character display. The original Palm units used a Film compensative Super Twisted Nematic (FSTN) display, which evolved to the Thin Film Transistor (TFT) reflective color display used in the Tungsten model. The first Palm Pilot 1000 had a 160×160 -pixel grayscale touch-sensitive display. The newer Tungsten unit from Palm has a 320×320 -pixel spatial resolution, with increased contrast resolution and support for 65,000 colors. Sony has licensed the Palm OS, and has released models with a similar 320×480 -color backlit TFT 16-bit display, that is larger and includes a Graffiti input region on the screen for display purposes.^{14,15,18,20}

The original Windows CE devices had a larger screen, with a 480×240 or 640×240 -pixel 4-shade grayscale display. The next generation of Windows CE v2.0 devices left the keyboard behind, and have 240×320 -pixel displays, usually with 16-shade grayscale or 16-bit color. The new Pocket PC 2002 units have a similar spatial resolution with 16-bit color, and

usually a 240×320 backlit liquid crystal display (LCD) TFT display.^{6,11,18}

Processors and Memory

The original Windows CE devices had 2–4 MB RAM and usually had processors with 36–44 MHz clock speeds. These devices were underpowered for Windows CE OS, and instability was a significant problem.^{15,18} The next generation of Windows CE v2.0 units had microprocessor speeds ranging from 60 to 130 MHz. The first Pocket PC 2002 units have the new 32-bit 206 MHz StrongARM processor and 32–64 MB RAM, with the newest devices including the new 400 MHz CPU.¹⁷

The original Palm devices had the Motorola DragonBall 16 MHz processor, which has increased only slightly to the 33 MHz 32-bit DragonBall VZ chip in the m505 and m515 models. Interestingly, this processor was similar to that found in the first Macintosh desktop computers. The amount of RAM has increased significantly, from 128 KB in the Palm Pilot 1000, to 8 MB in the m505, and 64 MB in the new Tungsten C. The new Palm Tungsten also has a 144 MHz enhanced ARM-based OMAP 1510 processor, and the new Tungsten C units have a 200 MHz Intel ARM processor. The newest Sony devices have a new CPU, the CXD2230GA, with a variable processor speed, ranging from 8 MHz to 123 MHz.^{12,14,20}

Expansion Methods

There are several expansion options for PDA devices. The industry standard for mobile computing expansion is the Personal Computer Memory Card International Association (PCMCIA or PC) card, first released in 1990. There are three types, with increasing thickness in size, and a width and length similar to a credit card. Type I is commonly employed for additional ROM or RAM, while Type II is often used for network connections, and Type III can be used for external hard drives, for memory expansion. This expansion interface device has a fast 68-pin connection, but PC cards are large in comparison to the size of a PDA, and require significant amounts of power to operate. Therefore they are not usually used in PDAs.^{6,11,21}

The CompactFlash (CF) card, first released in 1994, has been the industry standard for removable media in small portable devices, and it receives significant support from the SanDisk Corporation. These cards are about 25% the size of a PC card (close to the size of a matchbook), and are solid-state (no moving parts), use flash technology, and can fit into an adapter that allows them function through a PC card connection. These types of expansion cards are sometimes used with a PDA device through an adaptor connected to the PDA. Flash technology is a nonvolatile storage form (data is not lost without power).^{6,22}

The SmartMedia Card, created by Samsung and Toshiba, uses flash memory, and actually has different voltage allowances (3.3 volts and 5 volts, some can be both, but they must be the same as the device they are being used with). Because of the voltage differences, these cards have always had significant compatibility problems.^{6,11}

The MultiMediaCard (MMC) standard was designed by a joint effort of SanDisk, Siemens, and Hitachi. This card is about the size of a postage stamp, and it can provide an impressive amount of memory storage in that small space. These cards are also solid state, so there are no moving parts, and in PDAs are often used with the same interface as Secure Digital Cards (described below).^{6,11,14}

SanDisk, Toshiba, and Matsushita (creator of Panasonic products) collaborated to create the Secure Digital Card (SDC) standard in 2000. Like the MMC, these cards are the size of a postage stamp. They also have a similar solid-state interface, so that readers of SDCs can accept MMCs. Not all MMC readers can accept SDCs, however in addition to the memory storage of the MMC, the SDC has an I/O (input/output) interface that can allow connections with other devices such as a GPS unit. The memory size will continue to increase, and 2 GB SDCs are expected by 2004.^{6,14,23}

Sony and Fujitsu developed the Memory Stick standard. This type of media is larger than the SDCs (the size of a stick of gum), and is a solid-state technology. The Memory Stick supports the Secure Digital Music Initiative (SDMI) specification that was announced by the five largest recording industry companies in

1999, and is strongly supported by the Sony Corporation as a way to decrease illegal music copying (this specification is also supported in the SDC standard). The data-transfer rate of up to 2.5 MB per second is similar to that of an SDC.^{6,24}

The springboard module is a proprietary expansion card from Handspring solely for their PDA devices. These are the largest expansion modules in this discussion, but they also have the highest data-transfer rate, because they connect directly to the processor bus. Although these cards may require more power, their large size allows for inclusion of a battery pack in the module. There are currently over 70 different springboard modules available, including adapters for the SDC, MMC, and Sony Memory Stick, as well as cellular phone, GPS, advanced calculators, MP3 cameras, and basic digital cameras, but this expansion method is not included in the new communicator line of devices called Treo.^{6,25,26}

The expansion capability of PDA devices has evolved from the first Palm Pilot 1000, which accepted only a proprietary memory unit attachable to the back, to current Palm units, which accept SDC and MMC, as well as a Universal Connector, allowing use of digital cameras, keyboards, and GPS devices. The early Windows CE devices included support for PC and CF expansion cards. Modern Pocket PC 2002 devices include support for SDC, MMC, and CF cards.^{6,18,27}

There is an amazing variety of PDA accessories available. Some of the most popular include the portable keyboards, hard and soft cases, attachable QWERTY keyboards, digital cameras, different types of stylus pens, portable printers and scanners, and many network and cellular phone types of connections, including Bluetooth and Wi-Fi capabilities. The newest devices from Hewlett-Packard and Sony both have built in Bluetooth and Wi-Fi.^{20,28}

PALM OS VS. POCKET PC 2002

Since the release of the first Windows CE device, there has been an ongoing debate over the best OS for a PDA. The three most commonly used systems for PDAs are the Palm OS, Windows CE, and the Symbian OS. The Sym-

bian OS is not as widely used as the other two, and Psion is rumored to be leaving the PDA market altogether. The entry of Microsoft into the PDA arena was unusual, because, previously, only hardware companies had been creating PDA devices. Microsoft was creating only software, and relied on others to create hardware meeting their standards for running the OS. Thus, the Pocket PC 2002 units were required by Microsoft to move to the Strong-ARM processors, and to use Flash ROM, to increase ease of future upgrades, and to have reflective displays.^{6,15,29}

There are several areas of significant difference between the two most popular operating systems. In general, the Palm OS has been more stable, with an easier GUI, which has not changed significantly since 1996. The handwriting-recognition Graffiti software is easy to learn, requiring about 15 minutes to master. The Palm is sometimes described as the Apple of PDAs, with a simple interface that anyone can pick up and quickly navigate and use to input data. Palm itself has been relatively slow to incorporate multimedia, but the new Sony PDA devices incorporate a built-in 2 mega-pixel camera supporting UXGA resolution (1600 × 1200) with digital zoom, strobe flash, auto focus, and manual exposure adjustment; some video capabilities with MPEG-4 video; embedded Bluetooth; as well as Wi-Fi and the audio functionality, of a voice recorder and an MP3 player.³⁰

The original Windows CE devices had problems with a complicated GUI, instability, and rapid battery depletion. These problems have been partially resolved with the faster Strong-ARM processors from Intel, and the improved Pocket PC 2002 OS, incorporating multimedia and wireless communications. Some of the negative features of these units have been size (about twice as big as Palm OS units) and higher cost, approaching that of a much more powerful laptop computer. Nonetheless, sales of Pocket PC 2002 OS devices have grown significantly, in part secondary to support from the business sectors, decreasing the U.S. Palm OS market share from 71% in 2000, to 58% in 2001.³¹

The GUI of the Palm OS has historically been much easier to navigate than early

versions of Windows CE. The Open Launcher on the Palm OS allows programs to be categorized and opened simply by tapping on the selected icon with a stylus. The Pocket PC 2002 OS allows users to open applications through a Start menu similar to that in the desktop Windows systems. Both operating systems allow for character recognition, with the Palm OS Graffiti and the Pocket PC 2002 Block Recognizer, but Pocket PC 2002 users can also use a virtual keyboard, a transcriber, and a letter recognizer, similar to the original Apple Newton handwriting-recognition system, that attempts to interpret the user's natural handwriting. Both systems have a flashing light and audible alarm, and the Palm OS has a vibration alarm feature.^{14,27}

The ActiveSync with Pocket PC 2002 units continuously synchronizes the data entered with the desktop folder (defined by the user), automatically detecting changes in one or the other while the unit is in the cradle. The Palm OS units use HotSync, which requires the user to initiate synchronization. The exchange of data between Palm and Pocket PC 2002 units allows for infrared port beaming of applications and data. Current devices can beam to the other OS (Palm to Pocket PC 2002, or Pocket PC 2002 to Palm). Both systems have basic security functions preinstalled, and the Palm OS can assign passwords to only certain data. The Pocket PC 2002 devices can use a timeout password with four digits or a long alphanumeric text string.^{14,27}

Both OS units come with preinstalled applications for basic PIM, calculators, games, mail, security, etc. The Palm Desktop certainly has the advantage of having a simple GUI. The Pocket PC 2002 devices have Pocket Internet Explorer, a Voice Recorder, Pocket Word and Excel, and Windows Media Player, as well as MSN messenger, for instant messaging. Palm users rely on third party software to view Microsoft Word and Excel files.

Palm users can use devices with Internet abilities to view Web Clipping sites, and programs to view HyperText Markup Language (HTML) files, while Pocket PC 2002 users can use Pocket Internet Explorer to connect to sites with HTML or Wireless Application Protocol (WAP). The Pocket PC 2002 units have Virtual

Private Network (VPN) integrated support, while Palm users must obtain third-party software for such connections.

Both operating systems support up to 65,000 (16-bit) colors in their display systems, although the larger Pocket PC 2002 units often have a brighter display when compared side-to-side with the Palm. The Pocket PC 2002 units have integrated multimedia support, with Windows Media Player, whereas Palm OS users must rely on third party software. Both systems can function with Windows-based desktop systems, but only the Palm OS has native Macintosh support.^{14,27,28,30,32,33}

The recently released (read: since submission, and before revisions) new version of Windows CE is called Windows Mobile Software for Pocket PC—Mobile Windows, for short. This new version has promised many new additions, including “Zero Configuration Wi-Fi,” improved Bluetooth support, an enhanced Pocket Internet Explorer (pIE), and improved messaging support, contact and calendar, as well as an improved Windows Media Player.³⁴ Initial experiences with these devices demonstrates problems similar to those encountered the older Windows CE units, short battery charge, inconsistent synchronization, and some stability problems. The Wi-Fi abilities do easily detect nearby networks, but the actual connection is not as simple as advertised.

PDA's IN RADIOLOGY

There are several features of handheld computers that make them attractive in medicine. The ability to have a mobile or “walking library” available at all times can have a significant effect on patient care. Likewise, the ability to access patient-specific data, as through interaction with an electronic medical record (EMR), is a powerful tool. Fast and secure wireless connections will make this possible, and several industries have begun to recognize this fact. The increasing acceptance of Tablet PCs will contribute to the creation of future mobile software for radiology use. Most current residents and fellows have some PDA experience, and are more accepting of the small screen size and stylus interface, allowing ongoing transition to a paperless department as well as a

filmless one. The potential to edit databases of radiology procedures, track interesting cases, and share data on techniques and findings will contribute to this conversion (Fig 2).

Several software products have been developed for wireless PDA interaction with a Radiology Information System (RIS), in addition to an EMR system. There is also the inherent ability to use a Web browser on a PDA to view data or study images through a Web server that can be connected to a Picture Archiving and Communication System (PACS). PACS, radiology workflow, and administrative duties can be monitored with a wireless PDA. Some radiology information systems exist in a Web format, making the transition to PDA easier. There is even basic voice-recognition software for PDAs. Many types of reference materials can be made available on handheld platforms, providing powerful tools for teaching and for digital decision support (Figs 3 and 4). The mobility of these devices makes them potent tools as radiology becomes more of an expanded practice, with extension into outpatient imaging clinics.^{1,35-38}

PDA FUTURE

Palm is clearly moving to the ARM processors, similar to those used with Pocket PC 2002 units, and has now released the new wireless version of the Palm Tungsten device.¹⁴ The new Tungsten W phone unit, however, uses the Motorola DragonBall processor used in earlier Palm devices, with Palm OS 4, similar to the i705 wireless device previously released. This leaves the Palm Tungsten series with three very different processors, including the DragonBall, OMAP, and the XScale CPUs. Both the Pocket PC 2002 devices and new Palm OS units have also incorporated Bluetooth, the wireless short-range networking technology that allows data transfer at the rate of 1 Mb per second. Bluetooth technology deployment has been somewhat hindered by the poor specifications (from the Bluetooth Special Interest Group).¹⁹ The Pocket PC 2002 OS will continue to evolve, and the rapidly increasing technology advances with smaller, faster processors that have lower power requirements will make added multimedia and wireless communications features easier and



Fig 2. An example of a database list view for neuroradiology procedure cases created with HandBase® (DDH Software, Inc., Wellington, FL) on a Palm Tungsten W.

faster to use. The newest devices using both the Palm OS and Pocket PC OS include both Bluetooth and Wi-Fi.^{20,28,39,40}

In general, PDA technology will continue to advance, becoming smaller and faster. It is likely that both Palm and Pocket PC devices still will exist in 5 years, and there will be a market for each. There will be an increase in combination of technologies, so that a PDA, cellular phone, and pager can be contained easily within a small unit. The cellular phone is the ubiquitous mobile electronic device, followed closely by the pager, and then the PDA (which will pass the laptop in sales over the next few years). PDA security will become an increasingly important developmental field. There are countless unsecured wireless networks in operation, and in an effort to adopt new tech-

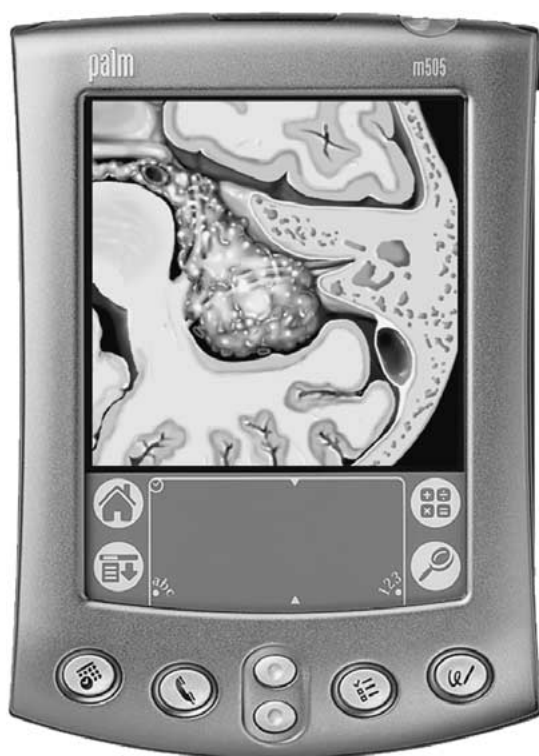


Fig 3. A medical illustration of a cerebellopontine angle epidermoid cyst displayed on a Palm m505 (used with permission⁴⁸).

nology early, some companies have adopted Wi-Fi and Local Area Network (LAN) wireless networks without any type of firewall, so that nonemployees can easily connect to the unsecure network with a Wi-Fi device simply by being within a certain distance of the network hub. In the next few decades, wireless networking technology will increase in speed and access distance and decrease in price, just as computer technology, has finally making the worldwide wireless networks a reality. Sony has focused on incorporating multimedia technology, and Nokia has developed a similar product, the Nokia 7650, using the Symbian OS and incorporating a PDA/cellular phone with an integrated digital camera, using the General Packet Radio Service (GPRS), which is a wireless communications standard with theoretical maximum speeds of up to 171.2 kilobits per second (Kbps).^{41,42}

Historically, the Palm OS units have been smaller, faster, cheaper, more stable, and have an easier to use GUI; they offer better third-party

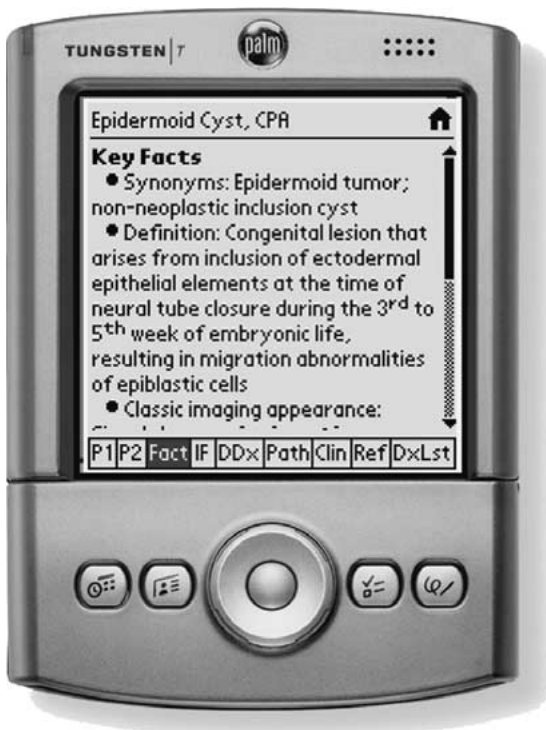


Fig 4. A text page from a PDA radiology book, displaying text about cerebellopontine angle epidermoid cysts shown on a Palm Tungsten T (used with permission⁴⁶).

support, are much easier to search, and they have easily twice as many applications available. The Palm OS devices, however, do not have the ActiveSync feature available in Pocket PC 2002 units, so there are relatively limited multimedia capabilities available. The Pocket PC 2002 units have an interface similar to the Windows desktop system, and are therefore potentially easier to use for those familiar with Windows and looking for a similar GUI in their PDA device. There are also more ways to input data in some Pocket PC 2002 units, and they offer increased VPN support (albeit a Windows-VPN only support). There is, however, no way to synchronize a Pocket PC 2002 OS unit with a Macintosh computer, which limits some options, without Virtual PC or similar software, such as the Pocket Mac.⁴³

With over 25 million Palm OS units sold, and a 72% worldwide market share in 2001, the Palm OS will remain the market leader for the next few years, but the Pocket PC 2002 units are increasing in popularity.⁴⁴ PDA sales will

increase significantly over the next decade, with an estimated worldwide PDA market increasing from the 13 million units sold in 2000, to over 63 million units in 2004, creating a \$26 billion market.^{44,45} Although worldwide PDA shipments decreased in 2002, European shipments of mobile devices increased by 72% in the fourth quarter of 2002, compared to the same period in 2001, and Palm sold 19% more devices than during the fourth quarter of 2001, double the sales numbers for the HP Pocket PC 2002 units.⁴⁶ Worldwide shipments of handhelds actually decreased in 2002, compared with 2001, by 9%, to 12.1 million units. This is likely secondary to the economic downturn. Palm remained the overall market leader, but saw shipments decline 12% in 2002, to 4.4 million units from 5.1 million units in 2001. Hewlett-Packard now holds the second overall spot in the PDA market and since the merger of HP with Compaq, is the market share leader for devices using the Pocket PC 2002 OS. Nevertheless, in 2002 HP worldwide shipments decreased by 27%, to 1.6 million units from 2.2 million units in 2001.⁴⁴⁻⁴⁶

The other leaders in the PDA market were Sony remaining in the number 3 spot, followed by Handspring, keeping three of the top four PDA market leaders running the Palm OS. The Palm OS continued to lead the handheld market in 2002, with 55%, or 6.7 million units shipped, using the Palm OS. About 25% of all handhelds shipped, or 3.1 million units, used the Pocket PC 2002 OS or another of version of the Windows CE operating systems.⁴⁵ During the US 2002-holiday season, the Palm OS devices maintained an 80% market share of sales, similar to 2001. There have been over 25 million Palm OS devices sold since their release, with the group of companies licensing the Palm OS continuing to grow, now including Acer, AlphaSmart, ARM, ATI, Fossil, Garmin, GSL, Handera, Handspring, HuneTec, Intel, Kyocera, Legend, MediaQ, Motorola, Palm, Samsung, Sony, Symbol, and Texas Instruments.⁴⁴⁻⁴⁶

An anticipated change in the Palm OS involves the main data-input system. After years of legal debate with Xerox, which claims that the Palm Graffiti system is too similar to their Unistroke character set, Palm will be leaving Graffiti behind and moving to a new system

they are calling Graffiti 2. Graffiti 2 is based on the technology of the JOT input system from Communications Intelligence Corporation, which has been included with Pocket PC 2002 devices. This allows dual-stroke characters that are closer to a natural handwriting style, and users can use standard upper and lower case printed letters.⁴⁷

CONCLUSIONS

The perfect choice of a PDA is as individual as the user. The intended uses of such devices vary greatly and should be considered first when selecting a PDA. As with desktop computers, it is easy to get confused with all the features, options, display differences, and overall technology. Also, because PDA technology is advancing so rapidly, it is difficult to keep current with the models and options available. The prospective user should begin with the intended use for the device, and then look at PDAs with the necessary options. The decision of which OS to purchase will then follow. If the device is to be used in an enterprise setting, the specifications will often be determined by the enterprise itself, similar to desktop purchases.

APPENDIX: GLOSSARY OF TECHNICAL TERMS

Bluetooth: short-range radio technology, usually used as a “cable replacement technology”

CF: Compact Flash

CPU: Central Processing Unit, essentially the brains of a computer

EMR: Electronic Medical Record

EPOC: PDA released by Psion, or the OS made by Psion

FSTN: Film compensative Super Twisted Nematic, type of flat-panel display screen

GPRS: General Packet Radio Service, a standard for wireless communications

GPS: Global Positioning Systems, a worldwide satellite navigational system

GUI: Graphical User Interface

Handheld PC: group of Windows CE devices that have a half VGA (640×240) or full size (640×480 or 800×600) screen with or without an integrated keyboard

HTML: HyperText Markup Language, authoring language of the Internet

ISP: Internet Service Provider, a company that provides access to the Internet

KB: Kilobyte, 1,000 bytes

Kbps: kilobits per second, or 1,000 bits per second

LAN: Local Area Network

LCD: Liquid Crystal Display, type of flat-panel display screen

MB: Megabyte, 1,000,000 or 1,048,576 bytes

MHz: Megahertz, one million cycles per second

MMC: Multimedia Cards

OMAP: Open Media Applications Platform

OS: Operating System

PACS: Picture Archiving and Communication System

PARC: Palo Alto Research Center

PC card: Personal Computer Memory Card International Association

PCMCIA: Personal Computer Memory Card International Association

PDA: Personal Digital Assistant

pIE: Pocket Internet Explorer

PIM: Personal Information Management

Pocket PC: group of Windows CE devices that have a quarter VGA (320×240) screen

RAM: Random Access Memory, place in a computer where the operating system, application programs, and data in current use are kept so that they can be quickly reached by the computer's processor

RIM: Research in Motion, company creating wireless devices

RIS: Radiology Information System

RISC: Reduced Instruction Set Computer, a type of microprocessor that recognizes a relatively limited number of instructions

ROM: Read-Only Memory, computer memory on which data has been prerecorded

SDC: Secure Digital Card

SDMI: Secure Digital Music Initiative, specification to attempt to decrease illegal music copying

Symbian: group of Psion, Nokia, Motorola, and Erickson in an effort to produce the next generation of wireless PDA devices using the EPOC OS

TFT: Thin Film Transistor, type of LCD flat-panel display screen, in which each pixel is controlled by from one to four transistors

UXGA: Ultra Extended Graphics Array, display specification capable of displaying 1600 × 1200 resolution, approximately 1.9 million pixels

VGA: Video Graphics Array, a graphics display system developed by IBM

VPN: Virtual Private Network, a network constructed by connect nodes

WAP: Wireless Application Protocol, secure wireless specification

Wi-Fi: wireless fidelity, meant to be used generically when referring of any type of 802.11 network

Windows CE: Windows-based PDA OS

WYSIWYG: What-You-See-Is-What-You-Get

REFERENCES

1. Flanders, AE, Wiggins, RH, Gozum, ME: Handheld computers in radiology. *Radiographics* 23:1035-1047, 2003
2. Webopedia: PDA. <http://webopedia.internet.com/TERM/P/PDA.html> . Accessed September 10, 2001
3. eTForecasts: WORLDWIDE PDA FORECAST 1998-2008. http://www.etforecasts.com/products/ES_pdas2003.htm . Accessed June 2003
4. Gasch S: Alan Kay. <http://ei.cs.vt.edu/~history/GASCH.KAY.HTML> . Accessed 1996
5. Handango: History of the Personal Digital Assistant. <http://www.handango.com/PDAHHistory.jsp?siteId=1> . Accessed April 17, 2001
6. Anderson D: PDAs. PC Tech Guide. <http://www.pctechguide.com/25mob3.htm>. Accessed August 1, 2001
7. TabletPCBuzz.com: From Whence It All Began: Dynabook. http://www.tabletpcbuzz.com/forum/topic.asp?TOPIC_ID=5564 Accessed August 9, 2003
8. Palo Alto Research Center Incorporated: Home > About PARC > History. <http://www.parc.xerox.com/about/history/default.html> . Accessed August 12, 2003
9. Research In Motion Limited: Company. <http://www.rim.net/company/index.shtml> . Accessed 2003
10. Casio, Inc: Watches. <http://www.casio.com/index.cfm?fuseaction=Products.catalog&catalog=Watches>. Accessed 2002
11. Chew J: Key Events After the Introduction of PDAs. National University of Singapore. http://www.thecore.nus.edu.sg/writing/ccwp10/james/pda_keyevents_post_intro.html. Accessed November 1, 2000
12. Palm Inc: Hardware Comparison Matrix. <http://www.palmos.com/dev/tech/hardware/compare.html>. Accessed 2002
13. Jokela S: Short Introduction to Personal Digital Assistants. http://www.tml.hut.fi/Opinnot/Tik-111.550/1999/Esitelmat/PDA/pda_final.htm. Accessed 1999
14. Palm, Inc.: Compare & Select a Palm™ Handheld. <http://www.palmone.com/us/products/compare/>. Accessed 2003
15. Fried I and Shim R: Pocket PC 2002 debuts. CNet. <http://news.com.com/2100-1040-273912.html?legacy=cnet>. Accessed October 4, 2001
16. Intel Corporation: Intel StrongARM Processors. <http://developer.intel.com/design/strong/sa110.htm>. Accessed 2003
17. Microsoft Corporation: Microsoft® Windows® Powered Handheld PC. <http://www.microsoft.com/catalog/display.asp?site=10617&subid=22&pg=4> . Accessed 2003
18. Verb: This Old PDA: Windows CE. <http://www.thisoldpda.com/wince1x/wince.htm> . Accessed January 26, 2001
19. Bluetooth Special Interest Group: About the SIG. <http://www.bluetooth.com/sig/about.asp>. Accessed 2003
20. Sony Style USA: Handhelds/PDAs > CLIE™ Handhelds > UX Series. http://www.sonymstyle.com/is-bin/INTERSHOP.enfinity/eCS/Store/en/-/USD/SY_DisplayProductInformation-Start;sid=Mb7NYUKWK9jNY33lemTHag2a3BeFcYIAjn8=?CategoryName=hp_UXSeries&ProductSKU=PEGUX50%2fU&Dept=hp . Accessed 2003
21. Ikeya B: PCMCIA home. <http://www.pc-card.com/main.cfm> . Accessed 2002
22. Compact Flash Association: Information about Compact Flash. <http://www.compactflash.org/info/cfinfo.htm>. Accessed August 21, 2000
23. Shim R: Secure Digital ready to make mark on flash. C Net. <http://news.com.com/2100-1040-269939.html?legacy=cnet>. Accessed July 13, 2001
24. Sony Corporation: Advantages of Memory Stick. <http://www.memorystick.com/en/ms/features.html>. Accessed 2002
25. Handspring: Smartphones: Overview. http://www.handspring.com/products/communicators/index.jhtml;jsessionId=OYLGVQQCMUQP1QFIAFCCFE4AVAARUIV0?prod_cat_name=Communicators. Accessed 2003
26. eXpansys Limited: Springboard Module Store. <http://www.expansys.us/handspring.asp>. Accessed 2003
27. De Herrera C: Pocket PC 2002 Comparison. <http://www.cewindows.net/wce/30/ppc2002/ppc2002comp.htm>. Accessed December 17, 2001
28. Hewlett-Packard Company: iPAQ h5555. http://www.shopping.hp.com/cgi-bin/hpdirect/shopping/scripts/product_detail/product_detail_view.jsp?BV_SessionID=&@0528170538.1064522120&@BV_EngineID=ccldadcjhlhgijfcngcfkmdfldfgg.0&product_code=900931&cat_level=1&browse link=true. Accessed 2003
29. BBC News. Psion pulls out of handheld market. <http://news.bbc.co.uk/1/hi/business/1433275.stm>. Accessed July 11, 2001
30. Sony Style USA: Handhelds/PDAs > CLIE™ Handhelds > NZ 90. http://www.sonymstyle.com/isbin/INTERSHOP.enfinity/eCS/Store/en/-/USD/SY_DisplayProductInformation-Start;sid=Mb7NYUKWK9jNY33lemTHag2a3BeFcYIAjn8=?CategoryName=hp_NZ90&ProductSKU=PEGNZ90KIT1&Dept=hp . Accessed 2003
31. Kane M: Palm's Market Position Eroses. CNet. <http://news.com.com/2100-1040-827272.html>. Accessed January 13, 2001

32. MacNeill, D: Choosing a Mobile Platform. Pen Computing Magazine. 36-39, Nov 2001
33. CNet staff: Handheld Operating System Showdown. CNet. <http://computers.cnet.com/hardware/0-1087-8-77988703.html?tag=st.co.1087-8-7798870-1.txt.1087-8-7798870-3>. Accessed November 14, 2001
34. Microsoft Corporation: Pocket PC > Software > Pocket PC 2003 Software. <http://www.microsoft.com/windowsmobile/products/pocketpc/about/2003/default.msp.x>. Accessed 2003
35. Epic Systems Corporation. EpicOnHand™ Handheld Access to Patient Information. <http://www.epicsystems.com/software/handheld.php>. Accessed 2003
36. IDX Systems Corporation. PDA Pocket Carecast. http://www.idx.com/carecast/cc_iwt.asp. Accessed 2003
37. Dictaphone Corporation. GoMD Dictate/Charge Capture. <http://www.dictaphone.com/products/mobility/gomd/>. Accessed 2003
38. Doctors Gadgets. Radiology Software for Palm and Pocket PC. <http://www.doctorsgadgets.com/medicalpda-software/radiology.htm>. Accessed 2003
39. Texas Instruments: Palm and Texas Instruments Engage in Far-Reaching Collaboration. <http://www.ti.com/sc/docs/news/2001/01224.htm>. Accessed December 17, 2001
40. Motorola DragonBall: Enabling the Next Generation of Wireless Devices. <http://ewww.motorola.com/collateral/DBBROCHURE.pdf>. Accessed 2002
41. Nokia: Home: Phones: Nokia 7650. <http://www.nokia.com/phones/7650/>. Accessed 2002
42. GSM Association: What is General Packet Radio Service?. <http://www.gsmworld.com/technology/gprs/intro.shtml>. Accessed 2003
43. Pocket Mac: Pocket PCs—not just for Windows any more. <http://www.pocketmac.net/>. Accessed 2003
44. The Inquirer: Palm, Sony did well selling PDAs in Europe. <http://www.theinquirer.net/?article=7435>. Accessed January 27, 2003
45. Shim, Richard: Handhelds continue steady slide. http://news.com.com/2100-1040-982286.html?tag=fd_top. CNET News.com. Accessed January 27, 2003
46. PalmSource, Inc.: Palm Powered Share Increases in Second Half of 2002. <http://www.palmsource.com/press/2003/012703.html>. Accessed January 27, 2003
47. Garfield, L: CIC Jot to power Graffiti 2. infoSync. <http://www.infosync.no/news/2002/n/2884.html>. Accessed January 13, 2003
48. Harnsberger HR: Head and neck image archive. Salt Lake City, Utah: Advanced Medical Imaging Reference Systems. Accessed June 2003